

ARIZONA'S WILDLIFE AND HABITATS (ELEMENT 2)

The State of Arizona contains approximately 73 million acres with a large range of topographic and geologic diversity. Elevations in Arizona range from about 75 ft above sea level (near Yuma) up to 12,643 feet at its highest point (San Francisco Peaks near Flagstaff). Generally, elevation increases moving from west to east and from south to north. Precipitation ranges from less than 3 inches to over 30 inches per year depending on elevation and location. Most precipitation in Arizona comes from summer monsoons and winter storms carrying moisture from the Pacific Ocean. The Sonoran Desert in the southwest corner of the State typically receives near equal amounts of summer and winter rain. Winter rain or snow dominates more in northern portions of the State, while summer rain dominates more in the southern portion.

Variability in climates, elevations, landforms, vegetative communities, watercourses, and soil types create many different environments throughout Arizona. These environments range through all 6 of Merriam's life-zones (Betancourt 1990, Brown 1994)—from the hot, dry deserts of southern Arizona through grasslands and woodlands in mid-elevations, to the cold, moist, montane and alpine forest environments in the higher elevations. In addition, isolated mountains throughout Arizona, known as “sky islands” (Marshall 1957), create steep elevation gradients assuring rapid environmental changes over very short distances.

Throughout Arizona, aquatic systems and associated riparian areas play a major role in maintaining biodiversity. Riparian communities along the aquatic habitat provide migratory birds and pollinating insects and bats with vital travel corridors for their migrations between North and South America. The State is home to a number of large rivers. The Colorado River runs through the Grand Canyon and forms the western boundary of Arizona. The Gila, Salt, and Verde rivers drain the northern-central portion of Arizona, and carry water to reservoirs supporting the cities in central and southern Arizona. Many smaller creeks and tributaries have perennial or intermittent flow. Springs, cienegas (marshes), and stock tanks provide valuable aquatic and riparian habitat and water for wildlife use. The complexity of the Arizona landscape gives rise to a diversity of habitats that support diverse wildlife communities.

Arizona ranks third in the nation for the number of native bird species, second for reptiles, fifth for mammals, and eighth for overall vertebrate animal diversity (Stein and others 2000). Wildlife that reside in or regularly migrate through Arizona include: 32 species of amphibians, 297 species of birds (not including accidental and casual migrants), 72 species of fish, 164 species of mammals, 145 species of reptiles, and over 20,000 species of macro-invertebrates (note: the Department has management authority over all vertebrate species and 86 known species of crustaceans and mollusks). Each of these species has associated habitat needs—shelter from the elements and predators, food and water, and materials and locations for nesting or raising young. Some species require very specific conditions that exist in only a few localized sites. For example, springsnails as a group exhibit narrow tolerances for spring water quality and substrates to forage on. Other species are habitat generalists, existing in or ranging across a variety of habitats. For example, coyotes are found statewide. Some wildlife, like migratory birds and bats, change their habitat requirements depending on season or life history stages. Arizona's wildlife depends on many resources at different scales in both space and time.

While Arizona supports a tremendous diversity of wildlife, it faces a variety of unique challenges and opportunities for wildlife conservation. Humans have the greatest impact on wildlife through their use of the same areas occupied by wildlife. Conservation opportunities are at this interface of land and resource use, yet as the agency responsible for wildlife management, the Department only has direct control over land use on lands it owns, only 0.05% of the total area of the State (Table 13). These areas comprise various Commission-owned Wildlife Areas, state fish hatcheries, the Ben Avery Shooting Facility, and administrative offices. The Department manages wildlife through its own actions as well as by interaction with major landowners and other resource management agencies. The US Forest Service (USFS), Bureau of Land Management (BLM), National Park Service (NPS), US Fish and Wildlife Service (USFWS), and Department of Defense (DOD) manage the largest portion (42%) of lands in Arizona. Most of these federal lands are unlikely to be subdivided and developed for commercial or residential uses. Most areas within USFS and BLM jurisdiction allow 'multiple-use' activities associated with recreational and economic pursuits. Federal agencies work under a variety of laws and policies in which conservation of wildlife is mandated. The Department works with these federal partners on land and water management projects on lands that they administer.

Tribal governments manage an additional 28% of land in Arizona. Each tribe is a sovereign nation, not subject to State jurisdictions. Most tribes maintain their own wildlife management departments. The Department continues to develop working relationships with the individual tribes to facilitate conservation of wildlife across the habitat types in Arizona.

The Arizona State Land Department (ASLD) manages 13% of the lands in Arizona. Under state law, these 'State Trust' lands are managed, leased, sold, and traded to provide revenue to support education in Arizona. These lands are primarily leased for commercial purposes or occasionally sold for private development.

Private lands make up 18% of Arizona's total area with concentrations near river corridors, watersheds, and other locations with important resources for wildlife. Because aquatic and riparian habitats are critical to many of Arizona's wildlife, private landowners have a large role in helping conserve wildlife populations.

Population growth in Arizona is among the highest in the nation. The population of Arizona grew 40% from 3.6 to 5.1 million from 1990 – 2000 (US Census Bureau 2000). Current estimates indicate an additional 13% growth in population from 2000 to 2004 (U.S. Census Bureau 2005). In particular, the desert urban centers, Phoenix and Tucson, are growing rapidly, but rural development is occurring throughout the State. Increases in human population impact wildlife through many processes, including but not limited to: conversion of habitat through urban and rural development; increased habitat fragmentation due to the proliferation of roads; dewatering of the State's habitat types through groundwater pumping and diversion of surface waters for municipal, industrial, and agricultural use; and increased pollution. All of these stressors (and more) will need to be managed proactively to insure that primary wildlife habitat and corridors connecting habitat patches are incorporated into planning.

Combined with the State's growing population, Arizona's mild winter climate and open spaces favor increased outdoor recreational pressures. As a result, many forms of recreation will require creative and proactive management to reduce stress to wildlife and natural habitats while insuring quality outdoor recreation opportunities for people. Changes in land status on State and federal lands and access restrictions on to and across private lands also add to the challenge of sustaining viable populations of wildlife, conserving natural habitats, and accommodating increased outdoor recreation, economic prosperity, and urban/rural growth across Arizona. Compounding this situation is the demographic trend of Arizona's residents shifting from primarily rural populations that are often more aware of local environmental issues, to an urbanized population less informed about the needs of wildlife and wildlife habitat.

Table 13. Land ownership in 2005 by ecoregion in Arizona.								
Percentage in each Ecoregion*								
Land Owner		AHN	AHS	AZNM	CP	MD	SD	Total
Federal	Bureau of Land Management	1.338	1.288	0.036	3.556	2.395	8.021	16.6%
	Bureau of Reclamation	0	0	0	0	0.017	0.148	0.2%
	National Forests	5.968	2.247	4.709	1.179	0	1.191	15.3%
	National Parks and Monuments	0.001	0.097	0.033	2.180	0.715	0.496	3.5%
	Military	0.000	0.147	0.036	0	0	3.739	3.9%
	Wildlife Refuges	0	0.159	0	0	0.046	2.138	2.3%
Total Federal Lands		7.3%	3.9%	4.8%	6.9%	3.2%	15.7%	41.8%
State of Arizona	AZ Game and Fish Dept	0.002	0.006	0.012	0.012	0.002	0.014	0.05
	State Trust	2.639	3.741	0.726	1.538	0.161	3.950	12.75
Total State Lands		2.640	3.750	0.740	1.550	0.170	4.150	13.00
Tribal Governments		3.569	0.376	1.726	16.489	0.032	5.380	27.57
Counties and Municipalities		0.005	0.001	0.001	0.002	0.005	0.201	0.22
Private		3.980	3.361	0.976	2.929	0.966	5.317	17.5%
Total		17.50	11.42	8.26	27.88	4.34	30.60	100%
*Percentages based on ASLD GIS data								

Arizona shares over 350 miles of border with Mexico. Many wildlife populations have annual migrations or movement patterns that cross these borderlands. The Department works closely with Mexican authorities and other partners through various committees, teams, and workgroups to assure the continued conservation of many borderland species. Illegal immigration traffic through the borderlands as well as homeland security border activities impact habitability of the border area and permeability of the border to wildlife migration. Conservation near the border will require politically astute strategies to address the needs of many stakeholders and affected wildlife.

Finally, drought has had a large negative impact on the habitats and wildlife of Arizona. Although the winter of 2004-05 provided a break in an overall 10-year pattern of drought, the

effects of that year's precipitation are difficult to observe on the current landscape. Recent surveys of game species show little response in terms of reproduction (fawn:doe ratios) resulting from last year's rainfall, and total counts are down to historic low levels for many surveyed species. Habitat monitoring data is less readily available, but visual observations indicate severe loss of rangeland biomass, many springs and cattle tanks without water, and high levels of impact to vegetation and soils due to livestock that is yet to be removed from rangelands. In winter 2005-06, Arizona has returned to an intensive period of little or no precipitation in the middle of a projected long-term drought. There has been little germination of winter annual vegetation and perennial vegetation is dramatically reduced in vigor. Much of the riparian, grassland, and desert scrub vegetation is considered severely over utilized, in places due to wildlife use, but more extensively as a result of livestock grazing. Forests are continuing their path through severe water stress, threat from insect infestation, and risk of catastrophic wildfire.

STRESSORS THAT IMPACT WILDLIFE AND WILDLIFE HABITATS (ELEMENT 3)

Arizona's wildlife and wildlife habitats have been affected by numerous land management actions and human activities throughout the state's history. Prior to Spanish occupation in the 1500s, the landscapes and ecosystems of Arizona were influenced by human activities. Aboriginal cultures used wildlife resources as forage, cultivated crops, diverted water, extracted timber, and may have used fire as a hunting tool (Turner and others 2003). Spanish settlers brought more agriculture to Arizona along with horses, sheep, and cattle. However, it wasn't until the 1880s when railroads linked the Arizona Territory with other states that Arizona's natural resources were effectively exploited and shipped elsewhere. Over the next few decades, mining, agriculture, timber harvest, and livestock production dominated the State's economy (Sheridan 1995). Over time these pioneering industries eventually gave way to emerging service and technological fields, but they still remain integral to Arizona's current economy and operate at varying levels of intensity throughout the State (Arizona Department of Commerce 2002). The impacts from historic high levels of these activities still persist in many of the state's landscapes and recovery of those areas to pre-settlement conditions is slow (Cooper 1960, Cooke and Reeves 1976, Turner and others 2003).

By the early twentieth century, new constituencies began to influence Arizona's economy. With the establishment of national forests, parks, and monuments by the federal government, tourism took hold in Arizona (Sheridan 1995). Over time, regulated hunting and fishing overshadowed subsistence harvesting of wildlife. Other outdoor recreational pursuits increased as well, especially after World War II, when Arizona's population growth accelerated.

Many current stressors to wildlife are related to the legacy of earlier use and stewardship of Arizona's landscapes. However, the most significant threats to Arizona's wildlife today stem from the state's explosive rate of population growth, ever-increasing demands on above- and below-ground water, modifications to ecosystems and communities from invasive species of plants and animals, and the current multi-year drought. Impacts from these sources are growing at a faster rate than from other sources, and the scale of these impacts cover enormous areas.

The intent of the Department's planning effort is to evaluate landscapes as they exist today and develop strategies on how best to make meaningful improvements to benefit species of greatest conservation need. This comprehensive effort will also address the many stressors that are based on legal and accepted practices. The Department recognizes that the manner in which a human activity or practice is conducted determines the degree of any negative or positive effects on wildlife and habitat.

Important stressors to Arizona's wildlife and wildlife habitat were identified as part of the CWCS process (Appendix O). Information gaps and research, survey, and monitoring needs related to these stressors limit the ability to make informed conservation decisions. These are some of the information needs identified in Table 3.

The following discussion of individual stressors is organized by stressor categories adopted from Salafsky and others (2003). This section does not address the relative importance or the magnitude of each stressor; it only describes the types of impacts associated with these stressors where they occur. Lists of stressors with significant impacts to ecosystem function and/or SGCN in each habitat in each ecoregion are found under "Ecoregion-Specific Habitat Conditions (Element 2)."

HABITAT CONVERSION CATEGORY

Habitat conversion through human-caused degradation and alteration is one of the most serious factors adversely affecting wildlife and plants worldwide. There are many causes of habitat conversion, including urban, residential, commercial, or recreational development; agricultural and livestock production; drainage of wetlands; altered hydroperiods; and development of dams and channels that regulate water flows. These factors affect habitats on a statewide basis.

These activities may ultimately cause habitat fragmentation and loss through landscape conversion, land clearing, road development, and increased vehicular traffic. The negative ecological impacts of fragmentation on natural systems have led many ecologists to identify habitat fragmentation as one of the greatest threats to biodiversity (Harris 1984, Wilcox and Murphy 1985, Noss and Cooperrider 1994). Adverse effects of habitat fragmentation on wildlife species and populations are numerous. Habitat fragmentation increases isolation of populations or species, which leads to decreased genetic diversity and increased potential for extirpation of localized populations or even extinction. Habitat fragmentation also alters vegetative composition and cover and the type and quality of the food base. Further, habitat fragmentation changes microclimates by altering temperature and moisture regimes, changes nutrient and energy flows, and increases opportunities for predation and exploitation by humans.

Urban growth

Rural development

Currently, population growth in Arizona is among the highest in the nation, growing 40% from 3.6 to 5.1 million between 1990 and 2000 (US Census Bureau 2000). Current estimates indicate an additional 13% growth in population from 2000 to 2004, and Arizona is projected to have the second largest proportional increase in population (108%) of any state in the nation between 2000 and 2030 (US Census Bureau 2005). While Phoenix and Tucson continue to grow as desert

urban centers, rural development is increasing rapidly throughout the State. This growth presents a number of challenges to wildlife conservation including but not limited to: habitat loss due to development; habitat fragmentation and degradation from networks of roads and utility lines; introduction of nonnative plants and animals that may be invasive and nuisance species; and increased demand for already limited water resources. Pima County was quick to recognize these threats and developed the Sonoran Desert Conservation Plan that integrates natural, cultural, and historical resource protection with urban growth (Ewing and others 2005).

Human resource use has led to a condition in which large areas of formerly continuous landscapes have become increasingly fragmented and isolated (Finch 2004). Urban, residential, commercial, and recreational development, agriculture and other such activities have accelerated over the past century, subdividing landscapes into disjunctive remnants of native ecosystems embedded in a matrix of anthropogenic land uses (Saunders and others 1991). Urban and commercial development contributes greatly to loss of native vegetation, increased water use, ground water depletion, and increased erosion through soil compaction and runoff concentration.

Growth of human population centers results not only in direct losses of habitat but is associated with other indirect pressures on wildlife and wildlife habitats. Even away from urban and agricultural areas, many valleys are dissected by major highways, railroads, canals, and utility corridors, occupied by power generating stations, feedlot operations, prisons, landfills, and military facilities, or inundated by reservoirs. All of these elements increase the spread of invasive plants. There is an ever-increasing demand for recreational opportunities in an ever-shrinking amount of open land.

Agricultural conversion

Livestock management

Agriculture operations include conversion of ecosystems to agricultural fields. This activity has dropped sharply with urbanization of the state. Livestock operations, however, continue to constitute the agricultural activity with the greatest potential to alter landscapes and impact wildlife.

Major changes in vegetation composition in Arizona and the Southwest have been linked to improper livestock grazing that occurred in the late 1800s when livestock numbers peaked (Leopold 1924, Cottam and Stewart 1940, Cooper 1960, Buffington and Herbel 1965, Humphrey 1987, Grover and Musick 1990, Archer 1994, Fleischner 1994, Pieper 1994). Preferred forage plants such as cool-season grasses declined, while weedy and unpalatable plants (prickly pear) and shrubs (for example mesquite and juniper) increased (Bohrer 1975, Bahre and Shelton 1993). Encroachment by junipers and ponderosa pine into riparian areas has also been significant and resulted in the loss of valuable vegetation components from the landscape.

These vegetation changes led to further landscape degradation. Historically, vegetation in well-functioning watersheds slowed the impact of falling precipitation, reducing erosion. Organic material at the soil surface also slowed runoff, allowing more recharge of soil moisture and subsurface aquifers. Improper grazing practices triggered significant levels of soil erosion, flooding, and arroyo cutting in the Southwest (Cottam and Stewart 1940, Smith 1953, Hastings

and Turner 1965, Cooke and Reeves 1976, Branson 1985, Humphrey 1987, Bahre 1991, Webb and Betancourt 1992, Felger and Wilson 1995). By the 1930's, Congress recognized that western rangelands were being degraded, and approved the Taylor Grazing Act of 1934. This act used permits to regulate the occupancy and use of the public land. The Federal Land Policy and Management Act of 1976 and the Public Rangelands Improvement Act of 1978 further guide the management of livestock grazing on public lands and are meant to speed restoration of public rangelands.

Unrestored landscapes compromise watershed condition. Watershed rangeland damaged from soil loss and altered plant communities affects the nature of runoff events into streams, rivers and lakes, and also groundwater recharge. Stream flow patterns have become more prone to high runoff events characterized by high velocities and silt loading, followed with dramatic reduction in flow. Currently many watercourses have been reduced from perennial meandering small streams and wetlands to gullies with ephemeral flows of high velocity and short duration. Gullies lower the effective wet zone below the reach of many riparian plant types, limiting banks to upland vegetation only.

The degree of impact of livestock grazing on wildlife habitat is largely dependent on the grazing management practices used (Holechek and others 2004). Grazing management variables that affect wildlife habitat include stocking rates, stocking density, the age and physiological condition of cattle, grazing season, forage selection, and cattle distribution. In addition, factors such as range condition, soil type, temperature, and precipitation also greatly influence the relationships between grazing and habitat quality for rangeland wildlife (Holechek and others 2004).

More informed grazing practices have been implemented on many private and public land tracts in recent years (Wilson and MacLeod 1991), but recovery of vegetation may take many years and is not possible on some sites (Fleischner 1994). For instance, many former grassland areas are now thin-soiled and vegetated by annual forbs and grasses, desertscrub brushland, or juniper woodland rather than their former deep-soiled perennial grass communities. Grazed upland forested areas in the Southwest have reduced understory grasses, with resulting dense tree recruitment and reduced fire frequency (Belsky and Blumenthal 1997). Many riparian areas have been impacted by grazing practices (Armour and others 1994; Belsky and others 1999)). Riparian areas have been badly incised due to flashy runoff conditions resulting from the denuded uplands. This directly removes deep sediments from the alluvial zone, leaving steep and rocky slopes in place of riparian floodplains. It also lowers water tables, drying up soils lateral to the channel, changing the plant communities to more xeric types, and dries up springs and seeps where wildlife may water. The preference of livestock to feed on riparian plants along with the cooler nature of the riparian zone and the presence of drinking water also leads to direct impacts to riparian zones by cattle. The ecological impacts of grazing are magnified in riparian systems, where livestock tend to congregate (Fleischner 1994; Belsky and others 1999). The widespread nature of livestock operations continues to superimpose current practices on impacts from earlier times or from other stressors.

Recreational sites/facilities

Pressure from the state's growing population to build new recreational sites and facilities and maintain existing ones may result in habitat loss and fragmentation. Ski resorts, marinas, golf courses, campgrounds, RV parks, race tracks, designated OHV use areas, and shooting ranges are interconnected by a series of roads that bisect the landscape, thus increasing the difficulty for wildlife to disperse or access necessary resources.

Forest and woodland management – habitat conversion

Forest management practices that consume habitat are discussed elsewhere. However, some harvesting practices result in conversion from one type of habitat to another, leading to changes in ecosystem composition and dynamics. For example, selective logging of juniper in Great Basin Conifer (pinyon-juniper) may promote the growth of monotypic stands composed primarily of pinyon. (Samuels and Betancourt 1982). When this occurs, there may be increases in susceptibility to disease and changes in fire regimes. The alteration in canopy cover can also negatively impact understory plant communities. Wildlife species may experience loss of desirable forage, cover, and nesting trees.

Dams/Reservoirs/Impoundments

Many aquatic and riparian habitats in Arizona have been altered and fragmented by dams and water diversions. Dams modify natural flows and alter water quality. Loss of flood pulses due to upstream regulation reduces the extent and frequency of floodplain processes such as leaching of salts, deposition of sediments and nutrients, rearrangement of structures and zones along rivers, and establishment of seedbeds for riparian plants. Reservoirs act as sediment traps and disrupt or alter the sediment budgets of downstream reaches. Decreases in sediment inputs alter the natural dynamics of mesohabitat creation and maintenance. Dams also fragment species ranges, preventing up and downstream movement of fishes and other aquatic and riparian species. Altered hydroperiods of seasonally astatic pools may reduce hydrologic connection to other wetlands, or other waters, reducing the quality of these habitats.

Landfills/dumps

The increasing influx of new residents to Arizona results in generation of large quantities of waste material which is then disposed of in landfills or dumps. These structures may harm SGCN and their habitat. Landfills and dumps are often large (sometimes more than 1 mile² in size), thus resulting in habitat loss, and are often associated with contamination and pollution in the surrounding environment. Densities of predators, such as scavenging dogs and corvids, may increase around disposal sites and result in harm to native species (Kristan and Boarman 2002). Additionally, increased heavy truck traffic on rural roads leading to the sites may negatively impact wildlife and wildlife habitat through collisions or by fragmenting the landscape.

Military bases

The Department of Defense (DoD) manages 3.9% of the land in Arizona. The Barry M. Goldwater Air Force Range is the largest DoD installation, covering approximately 1.7 million ac (0.7 million ha). It operates primarily for the support of research, development, testing, and evaluation of weapon and space systems, subsystems, and components. Other DoD installations in Arizona contain sites for live bombing, air defense missile firing, mechanized brigade training exercises, battalion-size or smaller training exercises, ballistic missile testing, aircraft takeoff,

landings and training courses, maintenance of fighter wing capabilities, and general military training exercises. While restricted access to many military lands provide substantial benefit to wildlife, military land uses also may destroy or fragment existing habitats.

TRANSPORTATION AND INFRASTRUCTURE CATEGORY

Roads for motorized vehicles

Trails for foot, bike, or equine use

Right-of-way fencing along roadways

Unauthorized roads and trails

Road and highway corridors have fragment habitats and landscapes (Saunders and others 1991, Reed and others 1996) dividing large landscapes into smaller patches and converting interior habitat into edge habitat. Studies in other states have demonstrated negative correlations between increasing road densities and wildlife populations (Lee and others 1997, Wisdom and others 2000). A 16 foot-wide road removes approximately two acres of habitat per mile of road. Accident report data compiled by the University of New Mexico documented an annual average of 828 large game animal/vehicle collisions has occurred since 1998 (Forman and others 2003). In a 10 year period the Department has documented 456 elk/vehicle collisions over a 30km stretch of Arizona State Route 260 (Dodd and others 2005). In addition to collisions with vehicles, roads facilitate legal and illegal killing and collection of many species, including big game as well as sensitive reptiles and birds. In the US Forest Service's Southwestern Region, 57% of threatened, endangered and proposed species under the federal Endangered Species Act, and 54% of US Forest Service's Sensitive Species are dependent on habitat within or affected by Inventoried Roadless Areas (USFS 2000).

Roads and similar structures influence stream characteristics, such as channel and floodplain configuration, substrate embeddedness, riparian condition, amount of woody debris, stream flow, and temperature regime (Furniss and others 1991). Timing of water runoff can change as roads and related drainage structures intercept, collect, and divert water. These factors can accelerate water delivery, resulting in an increase in the potential for greater magnitude of runoff peaks than in watersheds without roads (Wemple and others 1996). Road, trail and highway corridors serve as a means of dispersal for many nonnative and invasive plant species. Ground disturbance associated with the creation and maintenance of authorized roadways and trails provides additional opportunities for establishment of nonnative species (Parendes and Jones 2000, Gelbard and Belnap 2003). The creation of unauthorized roadways has many of the same influences on sensitive habitats with the added detriment of allowing access to those users who will, by their demonstrated willingness to ignore regulation, ignore other regulations which their unauthorized access facilitates (that is vandalism, poaching, illegal camping and fire building). Proliferation of unauthorized roads forces the resources of land management agencies, law enforcement agencies and public safety providers to be spread over more and more area, forcing increased expenditure of funds which were formerly devoted to wildlife and habitat management.

The impacts of roads on ecosystem services and directly on wildlife have drawn increasing attention in recent years. This has become an active field of research, engineering, and collaboration (FDOT 1999, Clevenger and others 2003, Forman and others 2003).

Power lines/wind-harnessing turbines

Telephone lines/cellphone towers

Wind energy facilities are not yet widespread in Arizona. However, as alternative sources of energy become more important to the state and nation and related technology improves there is potential for more wind-energy sites to be developed. Wind-generated electrical energy is environmentally friendly on the surface. It does not create air-polluting and climate-modifying emissions. Nevertheless, wind turbines, particularly in large arrays, can adversely affect wildlife and wildlife habitats. Wind turbine towers in particular have been associated with direct killing of bats and birds (particularly raptors) that strike moving blades (James and Baden 2004).

Lighted wind turbine, communications and transmission towers, which attract a variety of insect species, have the same potential to attract and kill night-flying migratory birds and bats (Rich and Longcore 2005). Lighting of towers in both urban and rural settings increases the density of birds at the hazard (glass barriers or lethal guy wires). Bird kills at lighted towers have been documented for at least 50 years (Rich and Longcore 2005). In the early 1960s, a 1,000-foot TV tower with guy wires was erected in Eau Claire, Wisconsin, with 11,000 bird mortalities documented in the first major collision.

Effects of utility corridors, including wind turbine farm access routes, include habitat fragmentation and disturbance from authorized and unauthorized use of access roads and pads; the increased incidence of direct illegal take, and the introduction of nonnative plant species due to the disturbance of soil and native vegetation during construction and maintenance (Parendes and Jones 2000).

Canals/pipelines

The arterial network of canals and pipelines designed to move water and fuel throughout Arizona may negatively impact wildlife and wildlife habitat. These structures are closely associated with development of utility roads as well as other maintenance activities. The resulting negative impacts may include, but are not limited to, habitat fragmentation, habitat loss and/or degradation, changes in community composition, water diversion, stream bank alteration or channelization, and providing a mechanism for facilitating movement of contaminants.

Dredging

Water sources are valuable for agriculture as well as recreational activities in Arizona. To ensure their persistence, water storage tanks may occasionally be dredged in order to remove excess sediment and vegetation. Reservoirs may also be dredged in order to facilitate watercraft access. These activities stir up the water column, potentially reducing water quality, and displace aquatic species. Machinery used for dredging may trample surrounding riparian vegetation or wildlife species.

Air traffic corridors/overflights

Air traffic can affect wildlife in a number of ways. Noise from low-level flights has been shown to cause startle responses in a number of mammal and bird species which may result in altered behavior and loss of reproductive fitness (Manci and others 1988). In addition, the Federal Aviation Administration maintains a database in which over 1100 civilian aircraft/wildlife collisions have been recorded in Arizona over the last 15 years. The vast majority of these are birds but some mammals have also been involved (The FAA National Wildlife Strike Database http://wildlife-mitigation.tc.faa.gov/public_html/index.html). Due to the voluntary nature of reporting, an estimated 80% of wildlife strikes are not reported and the actual impact may be much larger (DeFusco and others 2005).

ABIOTIC RESOURCE USE CATEGORY

Habitat disturbances from abiotic resource uses such as mining, oil and gas development, ground water depletion, and hydropower occur throughout Arizona, although they typically have localized impacts. Fuel drilling and development concerns are greatest in the Colorado Plateau and Arizona-New Mexico Mountain regions. Mining is a major operation in the Apache Highlands South Ecoregion in particular.

Drilling for fuels

Mining

Extractive resource uses such as mining and oil and gas development occur throughout Arizona and can influence ecosystem function, resilience and sustainability. On federal lands these activities are conducted under standards established by the Bureau of Land Management and are subject to further regulation by the Arizona Energy, Minerals and Natural Resources Department, Oil Conservation Division. Extractive resource uses may result in habitat fragmentation and loss through associated land clearing, road building, and disturbance from traffic, hauling and maintenance activities. Associated point-source pollution causes heavy metal and highly acidic water pollution (Drabkowski 1993, Starnes and Gasper 1996, Reece 1995), groundwater pollution (Miller and others 1996), air pollution, noise, and habitat conversion (Dinerstein and others 2000). Any of these activities and their adverse outcomes may ultimately lead to the reduction of wildlife populations.

Ground water depletion/springhead use

Groundwater levels in Arizona have dropped considerably due to pumping for agricultural and urban needs. Proposals and plans exist for additional desalination plants in Arizona. The surface water loss resulting from the water withdrawal and dewatering necessary to support anthropocentric water needs, exacerbated by drought conditions, will continue to influence habitats in Arizona. Lowered water tables affect all of Arizona's habitats, but can have considerable affects on small cienegas, springs, seeps and marshes and their associated SGCN. Spring "improvement," that is, capturing spring output in collection structures and either exporting the water or making it available to human determined uses, has significantly affected a large proportion of the springs around Arizona. This limits the extent of the wetted zone around the spring, the associated riparian plant community, and the associated wildlife community.

Water diversion/water catchments

Agriculture and urban areas increasingly depend on diversion and catchments to meet their water needs. Use of these tools may alter ecosystem hydrology by channeling water away from its natural flow regime. As a result, landscapes may experience severe erosion and decreased groundwater recharge which, in turn, may lead to changes in habitat.

CONSUMPTIVE USE OF BIOLOGICAL RESOURCES CATEGORY

Consumptive biological uses such as improper grazing practices, logging, fuel wood collection, and deforestation have the potential to affect SGCN and their habitats throughout Arizona. In areas where multiple consumptive biological uses occur (for instance in national forests), concerns persist about their ability to remain in a condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN.

Harvesting/collecting animals

Hunting, trapping and fishing are some of the methods by which wildlife species are harvested and collected in Arizona. Over harvesting may occur when more animals are legally (or illegally) collected from specific areas or during timeframes than is sustainable for the affected species. The often unique qualities of species residing in this state enhance their desirability as targets of both legal and illegal harvest/collection for national and international trade. The impacts to SGCN resulting from these activities may include, but are not limited to, changes in community composition, range contraction or eventual eradication/extinction, and decreased fecundity and recruitment caused by disease, pathogens, parasites, and hybridization. Because the Department manages wildlife resources in the state in a manner consistent with the North American Model for Wildlife Management, regulated consumptive uses has not had any negative impact on those species.

Harvesting/collecting plants

Harvest and collection of native plant species pose severe risks to vegetation communities across Arizona. Species such as saguaro cacti are illegally collected for use in landscaping. Overharvest of slow growing or reproducing species can lead to local or widespread extirpations. Not only do these activities degrade habitat quality, they may also cause changes in native fauna community composition. The remaining disturbed habitat may favor encroachment by nonnative species.

Forest and woodland management – consumptive use

Extraction of timber products is an important economic pursuit, but can have adverse effects on wildlife if not implemented wisely and responsibly. Over the last century, species composition and structure of Arizona's forests have been altered by the combined effects of commercial logging, fire suppression, and improper grazing practices (US Forest Service 1993, Covington and Moore 1994). Logging practices in Arizona and the Southwest have gone through differing management phases. In the late 1800s and early 1900s relatively indiscriminate cutting practices occurred (deBuys 1985), followed by selective logging in the mid-1900s, and even-aged timber stand management during the 1960s through 1980s (Bogan and others 1998). Extensive road networks were developed within the forests to allow easy timber removal (Allen 1989). Earlier logging practices tended to remove larger, older trees. More recently, logging techniques have moved toward more selective, uneven-aged silvicultural practices. Timber harvests from public forests have declined in recent years (Bogan and others 1998). Some emphasis has been placed

on federal endangered species habitat and ecosystem management. This has come about primarily through legal actions advanced under the Endangered Species Act, National Forest Management Act, and National Environmental Policy Act. Relatively recent Forest Service Region 3 directives require the maintenance of at least some old-growth forests for SGCN, such as the northern goshawk (*Accipiter gentilis*) and Mexican spotted owl (*Strix occidentalis lucida*). Fuel reduction is a focus of current forest management efforts, with millions of dollars directed at thinning small diameter trees and the reintroduction of prescribed fires to reduce the potential for widespread catastrophic wildfires (Bogan and others 1998). Indications are that 50% of the allocated monies will be expended on protecting human structures and neighborhoods in the wildland/urban interface areas.

In addition to the removal of overstory vegetation, the main impact of timber harvest has been the significant transportation system established to affect the removal of the product. Most of this road system is open to public use on a year-round basis except at the highest elevations in Arizona. This increased access for vehicular traffic has greatly increased the disturbance to resident wildlife, and is very detrimental to wildlife (in particular many bird species), which occupy high elevation forests during nesting and brood rearing periods. Off-highway vehicle traffic is also increased by developed roadways into otherwise inaccessible areas, and growing impacts from OHV use are a concern on many public lands.

Harvesting strategies over this period have shifted the condition from a patchwork of stands of variable age and composition to one that is in a modified, even-aged, second-growth condition. Previous harvesting strategies resulted in large areas that were cut and allowed to regenerate as even-aged stands of primarily ponderosa pine. These areas are significantly different in composition and probably in value to wildlife than the pre-settlement forests of the same area. The high stem density of these regenerating forests renders them more vulnerable to hot, destructive fire and disease. Forests of homogenous structure support a smaller number of communities and correspondingly less biodiversity than do forests with more structural diversity. Traditional practices of wildfire suppression also contribute to these trends in forest structure and composition. In recent years, timber harvest has been much reduced and fire suppression strategies have been changed with the expectation that this will begin a trend towards more diverse forests.

Grazing by ungulates

Unrestricted grazing by domestic livestock as well as wildlife in grasslands and along riparian areas has resulted in the reduction of long-term plant and animal productivity. Entire plant communities have been altered, which then results in decreased biomass and cover and increased impacts from precipitation. Rapid runoff from watersheds stripped of plant biomass and detritus increases stream velocities, leading to erosive downcutting and lateral destabilization. Downcut channels leave banks above the wetted zone, eliminating their suitability for riparian obligate vegetation and the associated enriched wildlife communities. Soil erosion from runoff increases sedimentation in streams and other aquatic systems. The change towards more weedy, unpalatable plant species decreases the availability of forage for animals as well. The preference of livestock and other grazers to feed on riparian plants along with the cooler nature of the riparian zone and the presence of drinking water also leads to direct impacts to riparian zones.

The ecological impacts of grazing are magnified in riparian systems, where livestock tend to congregate (Fleischner 1994).

NON-CONSUMPTIVE BIOLOGICAL USE CATEGORY

Recreational pressures on Arizona's landscapes are increasing due to the growing population, mild winter climate, and many open spaces. Popular outdoor activities include hiking, camping, hunting, fishing, sightseeing, wildlife-watching, watercraft and off-highway vehicle use, and other recreational and wildlife-oriented pursuits. The Department is committed to supporting a multiple-use policy (AGFC 1991) that assures quality wildlands are available to the public now and in the future. Under this policy, the Department's goal is to reduce stress to wildlife and wildlife habitats while insuring quality outdoor recreation opportunities for people. Changes in land status on State and federal lands and access restrictions onto and across private lands also add to the difficulty of sustaining viable populations of wildlife, conserving natural habitats, and accommodating increased outdoor recreation, economic prosperity, and urban/rural growth across Arizona. Habitat disturbances related to off-road vehicle use, military activities, and recreational use are a concern in large areas of Arizona.

Motorized recreation off-trail

Recreational off-road vehicle use can be found across the entire state. There are several organized events held each year. The specific effects of off-road vehicle use on Arizona habitats are incompletely understood. Off-road vehicle travel can cause damage to soils and vegetation (Holechek and others 1998) and impact wildlife by destroying and fragmenting habitat, causing direct mortality of wildlife, or altered behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983, Brooks and Lair 2005). The Forest Service has published in the Federal Register two proposed rules pertaining to offroad vehicle use. The first designates routes and areas for motor vehicle use and the second petitions states for inventoried roadless areas. Both of these proposed rules would impact future ATV use on Forest Service lands in Arizona. Other regulatory initiatives seek to improve ATV safety requirements and increase registration fees, with revenues targeted for the development of designated ATV trails and facilities. In areas where OHV use is popular, the increasing number of unauthorized roads will also have to be addressed.

The increasing population and dwindling amount of open land have increased the amount of recreational pressure on the areas that remain undeveloped. Balancing demands for hunting, hiking, wilderness preservation, birdwatching, and OHV recreation with wildlife conservation presents an ever-increasing challenge to resource managers.

Watercraft operation

Arizona waterways provide recreational enthusiasts with opportunities to operate motorized watercraft. Enhanced public access to previously inaccessible areas results in loss of undisturbed habitat for SGCN. Oily exhaust and fuel discharged from motorized watercraft decreases water quality and alters water chemistry. Wake and prop disturbance may alter habitat structure or physical characteristics to the detriment of SGCN. Noise and air pollution resulting from use of watercraft may also negatively impact fauna in surrounding ecosystem. Wildlife may be forced to change behavioral patterns.

Non-motorized recreation off-trail

Dispersed camping

Off-range recreational shooting

Skiing, hiking, hunting, fishing, mountain biking, rock climbing, camping, sightseeing, bird watching, and picnicking are popular recreational pursuits in Arizona (Conner and others 1990). Impacts to individual species has been document (for example, Swarthout and Steidl 2003), but the overall impact of these activities is not fully understood, nor is there a full understanding of how much recreational use can be tolerated before there is an adverse effect on wildlife or wildlife habitat. However, recreational activities are increasing and their potential effects on habitats and species should be considered in conservation planning (Conner and others 1990, McClaran and others 1992).

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Battles, maneuvers, war games, military camps (Military activities)

Arizona is home to several military installations. With its diverse landscape and climate, the state offers exceptional locations to conduct training exercises. These activities may include ground maneuvers (on foot or in heavy, motorized vehicles) or flight operations (helicopters and jets). Noise from motorized vehicles or aircraft may disturb SGCN by causing them to alter their behavior. Foot or vehicle traffic tramples native vegetation and wildlife species, compacts soil, disturbs wildlife, and fragments habitat. Land clearing for military camps and target areas results in habitat loss. Wildfires caused by military training have destroyed vast areas of desert habitat, including on adjacent national wildlife refuges (for example, 5,000 acres on Cabeza Prieta and 26,000 acres on Kofa in 2005). Direct injury or mortality from munitions testing is also possible.

Scientific research and collection

Scientific research is often necessary in order to gain a better understanding of wildlife behavior and their associated habitat needs. It offers important information to wildlife managers as well. However, scientific research and collection may negatively impact SGCN and their habitat. High levels of habitat disturbance may result from frequent visits to study sites. Frequent or inappropriate handling of wildlife may induce stress or inadvertently spread disease. Consumptive sampling techniques have the potential to negatively impact communities by altering reproductive and mortality rates.

POLLUTION CATEGORY

Concerns about pollution sources influencing Arizona's habitats are primarily focused on aquatic habitats. Pollution factors such as agricultural chemicals, livestock and dairy groundwater contamination, and solid waste can negatively affect the long-term persistence of SGCN in affected habitats. Runoff from urban road surfaces introduces nutrients and numerous contaminants to aquatic habitats. Mercury and petrochemicals have been identified in many of Arizona's reservoirs. Typically, pollution sources are regulated by various federal and state

agencies, such as the Arizona Department of Environmental Quality, which monitors water quality in Arizona's reservoirs. However, more information on the extent and sources of pollution in Arizona will aid conservation decisions.

Lead shot/fishing line

Lead is a heavy metal known to be highly toxic to humans and wildlife. Exposure to lead has increased substantially since the Industrial Revolution (Pain 1996). Due to human activities, lead has become ubiquitous in soil, air, and water at unnaturally high levels (Pain and others 1994). Lead poisoning in birds and mammals has been linked to several sources, including ingestion of spent lead gunshot (Pain and others 1994, Ma 1996), consumption of lead sinkers (Sears 1988), secondary consumption of lead contaminated prey (DeMent and others 1986, Frenzel and Anthony 1989), mining and smelting activities (Beyer and others 1997, Henny and others 2000), and firearms training facilities (Lewis and others 2001).

Discarded or lost fishing line and tackle represent a threat to wildlife in Arizona. Most wildlife/monofilament encounters derive from riparian birds collecting it for nest material (Hunt and others 1992, Beatty and others 1998), or specifically, bald eagles and osprey catching dead fish with fishing material attached. However there are other ways: animals can become entangled while visiting a lakes shoreline, they can ingest the material while feeding on a dead fish, and anglers can snag submerged riparian vegetation leaving the material exposed to wildlife when water levels recede.

Heavy metals/mine tailings

Heavy metals and mine tailings are toxic to humans and wildlife. Sources for these materials include, but are not limited to, mining operations (Rösner 1998), military ordnance, and leaded gasoline. They may also enter aquatic systems through urban and agricultural runoff. SGCN that ingest, are exposed to, or bioaccumulate these toxic materials may experience decreased fecundity through reproductive effects or increased mortality rates. Accumulation of these materials in the environment may alter water chemistry, decrease water quality, increase siltation, alter or reduce forage for insects and prey species, or decrease habitat complexity.

Pesticides/herbicides

Pesticide and herbicide use may influence ecosystem function, resilience and sustainability. The application of these materials for agriculture, landscaping (including golf courses) and vector control (for example mosquitoes) may result in decreased water quality, altered water chemistry, and reduction in forage for prey species (for example insects, aquatic species). Wildlife species may gain exposure to the contaminants through ingestion or transmission across the skin (for example amphibians have highly permeable skin). Bioaccumulation of pesticides and herbicides may increase susceptibility to pathogens and parasites and reduce fitness due to reproductive effects (Relyea 2005).

Nutrients/algal blooms

Sources leading to eutrophication (in other words, nutrient enrichment) of aquatic ecosystems include runoff from application of fertilizers for landscaping and agriculture, atmospheric deposition of nutrients, leakage from sewage and septic systems, and livestock waste. Algal

blooms supported by nutrient rich waters will decrease water quality, alter water chemistry, and deplete available oxygen. Shifts in available nutrients may also lead to changes in vegetation structure over time to the detriment of SGCN.

Illegal dumping/littering

The induction of non-biodegradable and other harmful materials through illegal dumping and littering may negatively impact SGCN and their habitat. Such materials may include, but are not limited to monofilament, hooks, lead shot, shotgun casings and boxes, heavy metals, hydrocarbons, broken glass, clay targets, and balloons. Wildlife may alter their foraging behavior or experience mortality as the result of ingesting the disposed materials.

Contaminants from waste water/runoff

Aquatic systems are inundated by contaminants in waste water with sources including, but not limited by, water treatment plant releases, roadways, gas stations, storm drains, septic tanks, industrial runoff, and feedlots. Wildlife may be affected through ingestion, exposure (for example amphibians have highly permeable skin through which materials may readily flow), and bioaccumulation. Contaminants decrease water quality and alter water chemistry, which may increase stress or mortality of SGCN. They may also increase the susceptibility of species to disease, pathogens or parasites. Ultimately, accumulation of contaminants may lead to severe habitat loss or degradation and eventually changes in community composition.

Sediment/ash flows

The institution of fire suppression during the early 1900s and land use practices (for example grazing) have led to unnatural fire regimes and higher than normal fuel loads across Arizona. Altered river and stream flows carry and deposit sediment in ways that can harm SGCN and alter the habitat. In the past, more frequent, low-intensity fires provided occasional sediment deposition required by some wildlife species. However, increased fire intensity and occurrence during different times of the year may produce more ash which may then inundate aquatic systems during periods of high runoff. Accumulation of sediment alters habitat and may reduce water quality.

Highway/roadway de-icing

Even though most of Arizona experiences relatively mild winters, some areas (for example, White Mountains, Mogollon Rim) experience significant snowfalls on average. In order to reduce vehicle collisions and accidents, Arizona Department of Transportation de-ices roadways and highways soon after snowfalls. The salt that builds up along the edges of roads attracts wildlife species, such as deer and elk, and increases the likelihood for wildlife/vehicle collisions. Accumulated de-icing material (for example salt) changes soil composition and chemistry so that it becomes less hospitable for native plant species. Additionally, spring runoff containing de-icing matter (including chloride) pollutes water sources and may cause decreased fecundity or increased mortality rates of wildlife species inhabiting those aquatic systems (Kaushal and others 2005).

Noise pollution

Both aquatic and terrestrial ecosystems may experience noise pollution resulting from vehicle traffic along roads, ATVs and off-road driving, construction activities, dams, military training, shooting ranges, city and urban activities, and motorized watercraft (for example, boats and jet skis). Noise disturbances may lead to altered behavioral patterns in wildlife, affecting their overall fitness (Weisenberger and others 1996).

Light pollution

The impact from light pollution varies from species to species, but has been shown to alter behavior of mammals, birds, reptiles, amphibians, fish, and insects (Longcore and Rich 2004, Rich and Longcore 2005). Within cities and urban areas, street lamps and construction zones provide continuous ambient light which may attract insects and thus those species that prey on them. Light from vehicle headlights may temporarily blind wildlife foraging along roadsides and thus increase the chances for wildlife/vehicle collisions. Bird kills at lighted towers have been documented for at least 50 years. In the early 1960s, a 1,000-foot tower with guy wires was erected at an Eau Claire, Wisconsin TV tower, with 11,000 bird mortalities documented in the first major collision. Lighting of towers in both urban and rural settings increases the density of birds at the hazard (glass barriers or lethal guy wires). In urban settings, the density of buildings generally increases the mortality rate for the same amount of artificial light.

INVASIVE SPECIES CATEGORY

Many ecologists have acknowledged the problems caused by invasion of nonnative species into communities or ecosystems and the associated negative effects on global patterns of biodiversity (Stohlgren and others 1999). Once established, invasive species have the ability to displace native plant and animal species (including threatened and endangered species), disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, DeLoach and others 2000, Zavaleta and others 2001, Osborn and others 2002). As of 1998, nonnative species have been implicated in the decline of 42% of species federally listed under the Endangered Species Act (Center for Wildlife Law 1999). At the federal level, the need for a coordinated effort to manage invasive species was recognized and The National Invasive Species Council was established in 1999 by Executive Order 13112 (Federal Register 1999). In 2005, the Governor of Arizona established an Invasive Species Advisory Council that is co-chaired by the Director of the Arizona Game and Fish Department and the Director of the Arizona Department of Agriculture.

Invasive nonnative species in Arizona have a variety of impacts on native biodiversity, and can affect native species through competition, predation, introduction of disease and parasites, hybridization, and others (Tellman 2002).

Nuisance plants

Among the most serious nuisance plants in southern Arizona are African bufflegrass (*Pennisetum ciliare*), red brome (*Bromus rubens*) and Saharan mustard (*Brassica tournefortii*), and a great deal of information is provided in various websites, including the Invaders webpage at the Arizona-Sonora Desert Museum (<http://www.desertmuseum.org/invaders/>). All of these plants, and several others, tend to grow in high densities and to carry wildfires in desert habitats,

resulting in wholesale changes in the vegetative communities (McAuliffe 1995, Esque and Schwalbe 2002). The Arizona-Sonora Desert Museum refers to Saharan mustard as "the worst invasive plant in the Sonoran Desert," primarily because of its competitive effects on other plants or its ability to carry fire (http://www.desertmuseum.org/invaders/invaders_saharamustard.htm). Structural differences that occur in desert habitats have unknown effects on reptiles, birds and small mammals, and the Department is initiating monitoring programs to examine some of those effects on desert lizards.

Riparian and aquatic exotic plants also negatively impact biodiversity. Tamarisk (*Tamarix* spp.) alter riparian communities, including bird, mammal and fish diversity (Kennedy and others 2005). Giant salvinia (*Salvinia molesta*) is becoming increasingly difficult to manage in the lower Colorado River.

The Southwest Exotic Plant Information Clearinghouse, a cooperative effort among USGS, NPS and Northern Arizona University, has organized comprehensive information on nonnative plant species in the southwest on one web location (<http://www.usgs.nau.edu/SWEPIC/index.asp>).

Nuisance animals

Nonnative aquatic species have considerable effects on all aquatic fauna in Arizona's aquatic habitats. Nuisance aquatic species include, but are not limited to, bullfrogs, crayfish, and nonnative fishes (Rosen and Schwalbe 1995, Fernandez and Rosen 1996, Rosen and Schwalbe 1997, Kiesecker and others 2001, Light 2003). Fernandez and Rosen (1996) documented wholesale alteration of a stream community in the White Mountains of Arizona. In terrestrial habitats near urban areas, landfills, recreational areas, and other areas modified by human activities, starlings, cowbirds, and ravens may displace native bird species (Kristan and Boarman 2002). Nonnative bees are also replacing native pollinators and potentially impacting vegetative communities (Schaffer and others 1983).

Feral animals

Escaped or abandoned domesticated pets, farm stock, and equines are severely impacting wildlife and wildlife habitats. Horses, burros, goats, domestic sheep, and hogs may overgraze or trample native plant species, thus increasing erosion, compacting soil through frequent trail usage, and polluting aquatic systems through waste accumulation. Feral cats are responsible for the death of thousands of birds across the U.S. each year (<http://www.audubon.org/local/cn/98march/cats.html>).

Bait-bucket dumping/illegal stocking

Aquatic systems and riparian species in Arizona are negatively affected by nonnative invasive species which have been released (legally and illegally) into the environment. Crayfish and other baitfish were introduced via recreational fishing activities and now compromise the persistence of many aquatic-obligate species (Fernandez and Rosen 1996). Release of non-native tiger salamanders for use in the bait trade threatens native populations (see below).

Diseases/pathogens/parasites

Many of the avian and mammalian SGCN are affected by diseases such as West Nile virus, rabies, hantavirus, pasteuria pneumonia, and Sylvatic plague. The growing wild land-urban interface exposes wildlife to potentially infected domestic and feral pets and may contribute to the spread of these diseases. Whirling disease in rainbow trout (*Oncorhynchus mykiss*) has led to adoption in Arizona of a "no tolerance" policy that bans the stocking or importation of fish infected with whirling disease, although the potential for accidental introduction still exists. Native frog populations have been decimated by the introduction of the fungal disease, chytridiomycosis, whose ultimate origin still remains unknown. Introduced species such as bullfrogs, African clawed frogs and tiger salamanders (introduced for the bait trade) are known to harbor chytridiomycosis, yet they experience few symptoms of the disease (see for example, Bradley and others 2002).

Around the world, recent disease outbreaks of West Nile virus, HIV/AIDS, hantavirus, avian flu, Lyme disease, and mad-cow disease started in other species but spread to humans. The spread of the disease illuminated the links between human neighbors and human health. Just as clearly, these diseases illustrate the large-scale disease threats that face wildlife populations even when they do not immediately spread to humans. All of the diseases listed above became outbreaks in association with human alteration of ecosystems.

Hybridization

Hybridization severely threatens the genetic integrity of native species, particularly those inhabiting aquatic ecosystems, through interbreeding with nonnative related species. For example, native fishes, such as Apache trout and Gila trout are threatened with hybridization (Carmichael and others 1993). Hybridization with non-native tiger salamanders, often imported for use in the bait trade, has been identified as a threat to endangered Sonoran tiger salamanders (Collins and others 1988).

CLIMATE CHANGE CATEGORY

Long-term changes in temperature and precipitation can have region-wide impacts. In the arid Southwest many ecosystem processes and the distribution and plant communities may be controlled primarily by soil moisture gradients (Griffin 1977, Pigott and Pigott 1993, Klopatek and others 1997). Drought and climate change can potentially have a substantial effect on Arizona's habitats. In coming decades, such changes are expected to produce major shifts in vegetation distributions at unprecedented rates (IPCC 1998). Recent research has shown that considerable vegetation changes have occurred in the past and can be expected in Arizona's future (Betancourt 1990, Brown and others 1997, Allen and Breshears 1998, Sprigg and others 2000). Often, these changes were a result of widespread mortality due to secondary effects such as insect infestations and fire.

Increased fire hazards, drought, and climate change present unique challenges for wildlife management planning because predicting their occurrences is uncertain. However, the effects of these processes are well known and need to be incorporated into management and policy plans (Clark and Cobb 2003).

Shift to warmer climate

The Southwest has been subject to a slight warming trend over the last 100 years that is expected to continue into the next century. According to climate prediction models, temperatures are expected to rise 4-5 °F by 2030 and 7-12 °F by 2090 (Sprigg and others 2000). Climate change may occur in the Southwest from increased atmospheric concentrations of CO₂ and other “greenhouse” gases. Effects may include increased surface temperatures, changes in the amount, seasonality, and distribution of precipitation, more frequent climatic extremes, and a greater variability in climate patterns. Such changes may affect vegetation at the individual, population, or community level and precipitate changes in ecosystem function and structure (Weltzin and McPherson 1995). They will likely affect competitive interactions between plant and animal species currently coexisting under equilibrium conditions (Ehleringer and others 1991). Plants respond differently to changes in atmospheric gases, temperature and soil moisture, in part based on their C₃ or C₄ photosynthetic pathways (Bazzaz and Carlson 1984, Patterson and Flint 1990, Johnson and others 1993). For example, increases in winter precipitation favor tree establishment and growth at the expense of grasses. Increases in temperature and summer precipitation favor grasslands expanding into woodlands (Bolin and others 1986). Increased winter precipitation has also been shown to favor shrub expansion in southeastern Arizona (Brown and others 1997). These same authors documented major changes in population dynamics and community composition of animals on the study site including local extinctions (including one keystone species) and decreases in formerly abundant species while other species increased in numbers. This indicates that any long term shift in climate could have potentially serious impacts on Arizona's wildlife.

Drought

Drought (an extended period of abnormally dry weather) is one of the principal factors limiting seedling establishment and productivity (Schulze and others 1987, Osmond and others 1987). Soil moisture gradients are directly altered by drought conditions. The distribution and vigor of some plant communities may be controlled primarily by soil moisture gradients (Griffin 1977, Pigott and Pigott 1993, Klopatek and others 1997)). Periodic drought is a normal component of the climate system in the Southwest (Clark and Cobb 2003). Drought affects wildlife and wildlife habitat through various means: it places additional stress on species for limited water resources (Sprigg and others 2000); increases susceptibility of forests to insect outbreaks and pathogens (Dale and others 2001); favors the spread of unwanted introduced species (Allen and Breshears 1998); alters ecosystem function (Franklin and others 1992, Dale and others 2000); and increases the possibility of large-scale wildfires (Sprigg and others 2000). In addition, recurrent drought may now be superimposed on climate change (see above). Drought and climate change can potentially have a substantial effect on Arizona's habitats.

CHANGES IN ECOLOGICAL PROCESSES CATEGORY

Changes in natural processes and ecological drivers (for example, unnatural fire regimes, habitat degradation, loss of keystone species) have influenced all habitats in Arizona and the Southwest. However, some habitats are more resilient or resistant to these modifications.

Habitat fragmentation/barriers

In the rapidly growing urban landscape throughout Arizona, both terrestrial and aquatic/riparian habitats are being fragmented and degraded. Within terrestrial systems, agricultural conversion

reduces habitat availability. Off-road vehicles, roads, phone and utility lines, and fencing bisect the landscape with an interconnected network of barriers that may restrict wildlife movement (for example, migration), increase mortality, alter fire regimes, degrade available habitat or resources, and alter community composition. Within aquatic systems, dams or streambank alterations may decrease water quality, change community composition, or restrict movement of species (in other words, restrict gene flow).

Habitat degradation/shrub invasions

Gori and Enquist (2003) documented a substantial decline in the area of grasslands throughout the Apache Highlands. Approximately 37% of historical grasslands have undergone a cover-type conversion to shrublands including juniper, mesquite, and catclaw, and an additional 32% will likely be converted to shrubland in the near future due to current land management practices. Conservation of grasslands is needed to maintain many grassland species, particularly wide-ranging species such as pronghorn. Ponderosa pines are also moving further into dewatered riparian areas, thus transforming entire communities. Habitat degradation and shrub invasions may cause habitat specialists to be extirpated or even to go extinct. Other SGCN may be forced to move and seek necessary resources in different locations.

Unnatural fire regimes

For thousands of years, wildfires have been an integral process in Arizona and southwestern forest and grassland ecosystems. Prior to 1900, naturally occurring wildfires were widespread in all western forests at all elevations (Swetnam 1990). From an ecological perspective, fire may be the most important disturbance process for many western forests (Hessburg and Agee 2003). Ecosystem processes and patterns are influenced and shaped by fire. These include soil productivity and nutrient cycling, seedling germination and establishment, plant growth patterns, vegetative plant community composition and structure, and plant mortality rates (Beschta and others 2004). Tree-ring and fire-scar data for the Southwest indicate that past fires were frequent and widespread (with an elevation range of variability) at least since AD 1700 (Swetnam and Baisan 1996). Within ponderosa pine and lower mixed-conifer forests and woodlands in Arizona, naturally-occurring wildfires were frequently of low-intensity and helped maintain stands of older trees with an open, park-like structure (Moir and Dieterich 1988). Higher elevation, mixed conifer and spruce-fir forests (wetter forest types) exhibited less frequent fire return intervals and fires were generally stand-replacing fires of higher intensity, (Pyne 1984, Walstad and others 1990, Agee 1993). The extent to which fire occurred in southwestern grasslands varied geographically and is related to climatic variables such as seasonal and annual rainfall and physiographic variables such as elevation, slope and aspect (Archer 1994). Fire may have been rare in desert grasslands and limited in extent due to low biomass and a lack of continuity in fine fuels (Hastings and Turner 1965, York and Dick-Peddie 1969). In more mesic grassland and savanna systems where fire was a prevalent and recurring force, pre-historic frequency and intensity appear to have been regionally synchronized by climatic conditions (Swetnam and Betancourt 1990).

The frequency, size, intensity, seasonality, and type of fires have changed throughout the Southwest (Dale and others 2001). The elimination of high-frequency, low-intensity wildfires across Arizona and the Southwest coincided with the reduction and/or elimination of fine

herbaceous fuels caused by improper grazing practices (Savage and Swetnam 1990, Swetnam 1990, Swetnam and Baisan 1996). These grazing practices further reduced grass competition, thereby increasing tree and shrub establishment (Archer 1994, Gottfried and others 1995, Belsky and Blumenthal 1997), which further altered natural fire cycles. Since the early 1900s, systematic fire suppression efforts have further curtailed the natural fire regimes that historically kept ponderosa pine, mixed conifer and spruce-fir stand densities and fuel loads relatively low. Fire suppression allowed the development of ladder fuels and the accumulation of heavy fuel loads. The frequency of large-scale, high intensity fires is increasing throughout the region (Sprigg and others 2000, Dale and others 2001). Catastrophic, stand replacing crown fires are now the standard, rather than the exception as a result of these changes (Covington and Moore 1994). Traditional practices of wildfire suppression have also contributed to these trends in forest structure and composition (Collier and Webb 2002). Land management practices and fire suppression have had adverse effects on many Arizona habitats through fragmenting, simplifying, or destroying habitats, and greatly modifying disturbance regimes (McIntosh and others 1994, Hessburg and Agee 2003). These human-caused changes have created conditions that are outside of the evolutionary and ecological tolerance limits of native species (Beschta and others 2004). Cumulatively, these practices have altered ecosystems to the point where local and regional extirpation of sensitive species is increasingly common (Rieman and others 1997, Thurow and others 1997). As a result, the integrity of many terrestrial and aquatic ecosystems has been severely degraded at the population, community, and species levels of biological organization (Nehlsen and others 1991, Frissell 1993).

Altered river flow regimes

River flow regimes may experience severe alterations from upstream dams, reservoirs, and impoundments. Altered flows change the physical parameters of rivers and streams such as temperature, salinity, nutrient loading, and sediment transport, which often then favor nonnative rather than native aquatic or riparian species. Reduced scouring frequency or intensity may allow increased sedimentation and accumulation of salts in the soils lateral to the channel, thus lowering water quality and riparian habitat viability for SGCN. Riparian vegetation dependent on water and nutrient availability and on reduction in salinities through soil leaching will recede, allowing further encroachment by non-riparian species. Nutrient regimes will also change within downstream aquatic and riparian communities. Unnaturally large flow events as a result of emergency discharge from reservoirs may cause flood pulses that exceed historical peaks, severely scouring channels and floodplains, causing direct mortality of plant and animal community elements, and sometimes resetting the successional scheme over vast extents of river and stream channels.

Soil erosion

Channelization and alteration of streambanks increases erosion through unnatural and excessive loss of soil. Hydrological changes will cause shifts in vegetative cover necessary for maintaining intact ecosystems. Erosion due to wind and water action will increase siltation, decrease water quality, and lead to loss of riparian habitat diversity and complexity.

Streambank alteration/channelization

Human presence on the Arizona landscape has always required water sources to be modified to their use. Diversion of streams for agriculture occurred at least as early as the Hohokam and other early agriculturalists. In early settlement times, many wet meadows and cienegas were drained to create farms and pastures, or to use the water elsewhere. Reduction to risk from flooding has likewise been a concern, causing the human community to seek methods to restrict watercourses to pre-determined paths. Both of these trends have continued to modern times, sometimes being implemented on truly landscape scales, such as along the Colorado River in western Arizona. Historic flood-control efforts have reduced some once vital riparian systems to concrete-lined ditches without significant biotic components. Humans have thus changed the natural flow regimes of rivers and runoff. The results of these changes include loss of riparian habitat, drying of natural springs and seeps, modification of springheads, and depletion of groundwater supplies. Both wildlife and plant species experience severe habitat degradation and loss and may be unable to reproduce or persist. These altered ecosystems may promote nonnative species invasions or encroachment by non-riparian species. More recently, some softer approaches incorporate a desire to preserve biotic resource values, but often the constraints imposed to control flooding inherently limit the outcomes to levels of quality and quantity far below the historic values.

Loss of keystone species

Keystone species, such as beavers (*Castor canadensis*), bison (*Bison bison*), and prairie dogs (*Cynomys* sp.), are species that have a large overall effect, disproportionate to their abundance, on the structure or function of habitat types or ecosystems (for example, Wilmsers and Getz 2005). Many keystone species in Arizona are pollinators, where desert plants rely heavily on insect, bird, and bat pollination. Pollinators rely in turn on a minimum level of pollen resources, so they can be affected by habitat loss or degradation (Kremen and others 2004). If a keystone species is extirpated from a system, other species that are closely associated with the keystone species will also be affected and perhaps disappear. In Arizona, several keystone species have either been completely removed or have experienced significant population reductions in their historic range. With their removal or reduction in population levels, other species population levels variously decline or benefit.

Insect infestations

Phytophagous (plant-eating) insect outbreaks cause tree mortality and reduced growth in Arizona's forests and woodlands (citations). Bark beetles and inner bark borers are primary tree killers (Haack and Byler 1993). Phytophagous insects have traditionally been considered detrimental to forest health and commercial timber harvest (Schowalter 1994). However, most phytophagous insects that affect forest trees in Arizona are native organisms (Wilson and Tkacz 1994) and, from an ecosystem perspective, perform functions that are instrumental in sustaining forest health and function through succession, decomposition, nutrient cycling and soil fertility (Haack and Byler 1993). Altered forest conditions have likely increased the frequency, intensity, and extent of insect outbreaks and diseases (Haack and Byler 1993, Wilson and Tkacz 1994). Changes in forest tree age, size, density, species composition, and vertical stratification across temporal and spatial scales influence patterns of forest insect herbivory at the ecosystem and landscape levels (Schowalter and others 1986). Environmental stresses such as drought, late spring frosts, wind throw, and air pollution can encourage insect outbreaks (Haack and Byler

1993). Although insect outbreaks in forest ecosystems occur naturally, they can cause shifts in vegetative species composition and structure (Haack and Byler 1993). Further, certain phytophagous insects are attracted to fire-damaged or fire-killed trees and their build-up in weakened host trees can threaten adjacent, unburned stands (USFS 2003, 2004b, 2005). The magnitude of disturbance from an outbreak depends upon the particular insect or pathogen, and on the condition of the forest ecosystem affected (Wilson and Tkacz 1994). Closely spaced host trees are likely to trigger outbreaks of phytophagous insects and pathogens. In compositionally and structurally diverse forests, however, potential host trees can be harder for insects to locate among non-host trees, and vulnerable host trees may be relatively resistant to small numbers of insects that find their way through the surrounding non-host vegetation (Hunter and Aarssen 1988, Waring and Pitman 1983). Outbreaks are typically worse in single-species, monocultural tree stands especially during vulnerable periods such as drought (Mattson and Haack 1987, Schowalter and Turchin 1993, Waring and Pitman 1983). Populations of most foliar and sap-feeding insects peak during particular stages of host-tree development (Schowalter and others 1986), which make monoculture stands of single-aged trees more susceptible to outbreaks. Drought provides a more favorable environment for phytophagous insect growth, survival, and reproduction, and may reduce the effectiveness of the biochemical defense system that some plant species have evolved (Mattson and Haack 1987).

Domestication of wildlife/game farming

Wildlife maintained within game farms pose risks to native wildlife species should they escape or intentionally released. They may hybridize with native species, thus reducing genetic integrity. They may also introduce harmful disease, pathogens, or parasites to wildlife.

Management for game animals and sport fish

Game animals and sportfishes are actively managed through stocking, development of water sources, and permits for harvest and collection. Animals and fishes typically managed in this manner include, but are not limited to, elk, mule deer, waterfowl, rainbow, brook, and brown trout, and largemouth bass. The techniques used promote persistence of nonnative species that displace, compete with, or prey on native species. They may also influence species assemblages and populations through additional habitat modifications. Some management practices can also be beneficial to SGCN. For instance, wildlife water developments built for large ungulates are used by many other species.

INTERNATIONAL BORDER ISSUES CATEGORY

The volume of illegal immigration and drug smuggling across the border has increased dramatically in recent years, resulting in severe impacts to habitats. Border security measures are being stepped up throughout the Arizona/Mexico borderlands region to address this activity (US Department of Justice, Immigration and Naturalization Service 2000). Associated road and barrier construction and enforcement patrols and pursuits in the borderlands region causes additional habitat loss and fragmentation, reduces effective (usable) habitat for wildlife populations, increases road kill, poaching, illegal collecting of wildlife and general habitat destruction (Forman and others 2003). Some stressors listed below stem from illegal immigration and smuggling, others from law enforcement along the border, and still others from movement of animals across international borders.

Dispersed camping along the border

Unauthorized roads and trails created by illegal immigrants and smugglers

Undocumented aliens camp in undesignated areas along the Arizona/Mexico border and sometimes along heavily used routes many miles from the border. Camps and routes tend to be in areas that offer concealment and so are often located in sensitive riparian areas. Heavy foot traffic tramples vegetation and increases soil compaction, which degrades wildlife habitat. Wildfires from campfires that may burn vast expanses of the landscape are becoming increasingly common, and the amount of waste deposited along riparian areas and within streams is increasing, resulting in decreased water quality. SGCN inhabiting these areas will be most affected by alterations within their habitat, however direct disturbance, collecting, and killing by people is also possible. Related to the issue of camping is habitat destruction caused by smuggler foot and vehicle traffic. Border areas are experiencing a rapid proliferation of foot trails, some of which approach the width of one-lane roads. Vehicle drive-throughs across the open desert are also increasingly common. In areas of the most intense activity, landscapes are lined with a multitude of parallel foot and vehicle routes. Impacts to habitat include destruction of vegetation, soil compaction, and erosion. The disturbance caused by the presence of humans in remote backcountry areas can cause direct harm to wildlife. An example of this is disturbance of Sonoran pronghorn during fawning. Legal visitation in Sonoran pronghorn habitat is restricted during this critical time, but illegal travel from across the border is rampant.

Illegal dumping/littering along the border

Dumping and littering along the border and along smuggling routes to the north by illegal aliens introduces non-biodegradable and other harmful materials to wildlife habitats. Vehicles are commonly left abandoned in desert areas when they break down, become stuck, or are pursued by enforcement officials. All of these materials degrade habitat quality and have the potential to attract invasive or feral animals that carry transmissible diseases or will out-compete or prey on native wildlife species.

Water use/contamination by illegal immigrants and drug smugglers

Water along the Arizona-Mexico border is subject to overuse and contamination by illegal aliens, which may negatively impact native species. SGCN may avoid aquatic habitats that are degraded by vandalism and litter. This may result in the loss of necessary resources for survival. Water sources may dry completely when border crossers leave valves open or vandalize water developments to obtain water, and aquatic species may then be extirpated from a site. Terrestrial species will be forced to search for alternative water sources, which are sparse across an arid, desert landscape.

Altered fire regime as a result of border activities

Illegal aliens crossing the border from Mexico to Arizona build fires for warming or cooking as well as to create smoke diversions for avoiding detection. Because the camps are typically in areas of heavy, concealing vegetation and the fires are commonly left unattended, the risks of them developing into larger wildfires are considerable. The increased frequency and intensity of wildfires leads to habitat loss and degradation, increased soil erosion, reduced cover for SGCN,

altered hydrology, and increased ash flow and sedimentation. Fires may also increase species mortality rates or susceptibility to disease, pathogens, and parasites.

Disease along the border

Dense populations of people residing in Mexico along the border with Arizona increase the threat of disease to wildlife in this state. Pet or feral dogs and cats may transmit rabies, distemper, or other diseases to SGCN, and livestock may transmit diseases to native ungulates, particularly bighorn sheep. If actions are not undertaken to minimize stagnant water sources, West Nile Virus may continue to threaten the persistence of avian SGCN (particularly corvids) living or migrating through the borderlands area.

Enforcement activities along the border

Not only do activities by illegal aliens impact wildlife and their habitat along the border, so do borderlands enforcement activities. Enforcement agencies may fragment or degrade habitat or harm wildlife by creating and maintaining roads, fencing, and barriers, using four-wheel drive vehicles and ATVs offroad, and conducting overflights and rescue operations with helicopters. With the increase of illegal alien activity in recent years, and national security concerns resulting from September 11, the Department of Homeland Security is greatly expanding its prevention and apprehension efforts. Noteworthy among these are the ongoing construction of vehicle barriers along the border across Organ Pipe Cactus National Monument and the Yuma Desert (and planned for Cabeza Prieta National Wildlife Refuge), construction of many miles of patrol and access roads, and installation of stadium-style lighting in some areas, including along part of the Colorado River. In addition to the direct impacts to wildlife and habitat, the increased level of activities at the border may promote nuisance plant invasions, altered fire regimes, soil erosion, and pollution of waterways. The effects of these activities on SGCN may include, but are not limited to, behavioral changes, decreased fitness, and mortality.

Roads and trails created for law enforcement along the border

Law enforcement agencies construct roads and trails for patrolling and to gain access to areas where illegal aliens are crossing the border. These vary from unintentional creation of "2-tracks" by repetitive driving off-road, to major construction projects. Some roads are created or widened during "dragging" activities to create smooth surfaces for track detection. Creation of roads destroys cacti and other vegetation and entire ecosystems may change to become less hospitable for native species. Once in place, public use of these roads increases and so does human disturbance to once remote and pristine regions. The roads and trails also serve as barriers for some SGCN, thus restricting ranges and impairing their abilities to obtain food or find mates. Increased traffic along these roads may augment opportunities for introduction and establishment of nonnative, invasive vegetation.

Enforcement fences along the border

Fencing and other barriers constructed along the Arizona/Mexico border to prohibit the illegal entry of immigrants, drug smugglers, and their vehicles into the U.S. also fragment and degrade wildlife habitat. These structures impede movement among habitats that provide resources necessary for survival. Fences along the border contribute to the imperilled status of the U.S. Sonoran pronghorn population by restricting their movement. In the past, these animals

depended on being able to move throughout their range in order to obtain food and water. Bighorn sheep and deer may also be adversely impacted in some areas by their inability to move across the border. Movement restrictions may reduce reproductive opportunities within small populations and result in loss of genetic integrity or decreased fitness.

Light pollution along the border

In order to better spot illegal aliens crossing the border, law enforcement agencies use large spot lights, vehicle headlights, and stadium-style lighting. Light pollutes the environment and may alter the behavior of nocturnal species such as bats, rodents, and predators. The disruption of natural light availability may even alter circadian cycles.

Enforcement overflights along the border

To discourage and search for illegal aliens, Department of Homeland Security regularly conducts flights along the border. Frequent trips during both day and night may disturb SGCN. Noise pollution from aircraft might impair hearing of wildlife, alter their behavior or induce stress, or cause them to move out of the area, if possible.

SYNERGISTIC EFFECTS OF FACTORS INFLUENCING SPECIES AND HABITATS

It is difficult, and perhaps impossible, to separate individual causal factors that influence habitats or SGCN. Multiple factors are closely linked in cause and effect relationships across spatial and temporal scales. Adverse effects from multiple ecosystem stressors can have cumulative effects that are much more significant than the additive effects alone, with one or more stressors predisposing biotic organisms to additional stressors (Paine and others 1998). For example, reduced fire frequency from a century of fire suppression is partly responsible for conditions that have allowed major outbreaks of several phytophagous insects (Peet 1988). Further, unusually dry periods and/or climate changes reduce available soil moisture causing water associated stress, reduced xylem pressure and pitch production in trees. These conditions allow insects to bore into and infect and kill trees. Affected stands with high tree mortality quickly accumulate dead standing and downed woody fuels. In turn, these conditions greatly increase the risk of catastrophic, stand-replacing wildfire and subsequent insect attack on trees injured or weakened by the fire (Gara and others 1985). To further illustrate the interactive and synergistic effects of these factors, consider historic grazing practices that reduced fine fuels and affected natural fire cycles. This condition, in combination with a century of fire suppression and multiple years of drought has created unnatural stand and fuel conditions, making forest and woodland habitat types increasingly susceptible to stand-replacing catastrophic wildfires. Add to this mix, insects and diseases linked with decreased forest health. The overall impact converts late-successional mixed conifer forests to early-successional grasslands, shrublands and recovering forests. Roads contribute to habitat fragmentation and are linked as well to other major habitat altering factors such as timber removal, fire ignition and suppression, fuel wood collection, and recreation. The effects of climate change on ecosystems and species are likely to be exacerbated in areas that have already been substantially affected by human activities such as habitat loss and fragmentation, air and water pollution, and the establishment of invasive species. Habitat fragmentation decreases the ability of plant and animal species to migrate in response to changing conditions or species requirements. Invasive species are most successful in ecosystems already disturbed by anthropogenic activities (Elton 1958). Climate change may act as a form of

disturbance creating opportunities for invasive species to colonize and displace native species (Malcolm and Pitelka 2000). When suitable habitat conditions disappear or shift faster than populations can adjust, the likelihood of species extirpation or extinction increases (Malcolm and others 1998).

Many of the factors discussed above coincide in the same geographic area. Given the synergistic effects of multiple factors, it is difficult to understand the overall impact these factors will have on Arizona landscapes, habitats, or Species of Greatest Conservation Need. In addition, it is difficult to understand which habitats may have higher risk of being altered by multiple factors. The ability to describe and address these risks only begins with the current process, under which the Department compiles information on individual stressors or individual sources.